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DELAWARE RIVER WATERSHED, NEW  
YORK, PENNSYLVANIA, NEW JERSEY,  
DELAWARE, AND MARYLAND.

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30  
LETTER

FROM

SECRETARY OF AGRICULTURE

TRANSMITTING

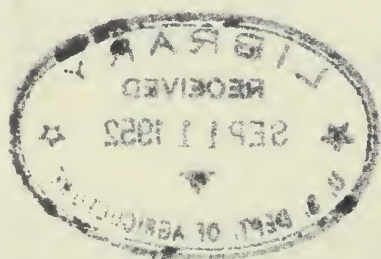
A SURVEY REPORT DATED OCTOBER 1950, TOGETHER  
WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS  
OF THE DELAWARE RIVER WATERSHED IN NEW  
YORK, PENNSYLVANIA, NEW JERSEY, DELAWARE,  
AND MARYLAND, MADE UNDER THE PROVISIONS OF  
THE FLOOD CONTROL ACT APPROVED JUNE 22, 1936,  
AS AMENDED AND SUPPLEMENTED.



2a  
MARCH 28, 1952.—Referred to the Committee on Public Works  
and ordered to be printed with illustrations

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50  
UNITED STATES  
GOVERNMENT PRINTING OFFICE  
WASHINGTON : 1952



## LETTER OF TRANSMITTAL

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DEPARTMENT OF AGRICULTURE,  
OFFICE OF THE SECRETARY,  
*Washington, March 19, 1952.*

The SPEAKER, HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am submitting herewith a survey report dated October 1950, together with accompanying papers and illustrations of the Delaware River watershed in New York, Pennsylvania, New Jersey, Delaware, and Maryland, made under the provisions of the Flood Control Act approved June 22, 1936, as amended and supplemented.

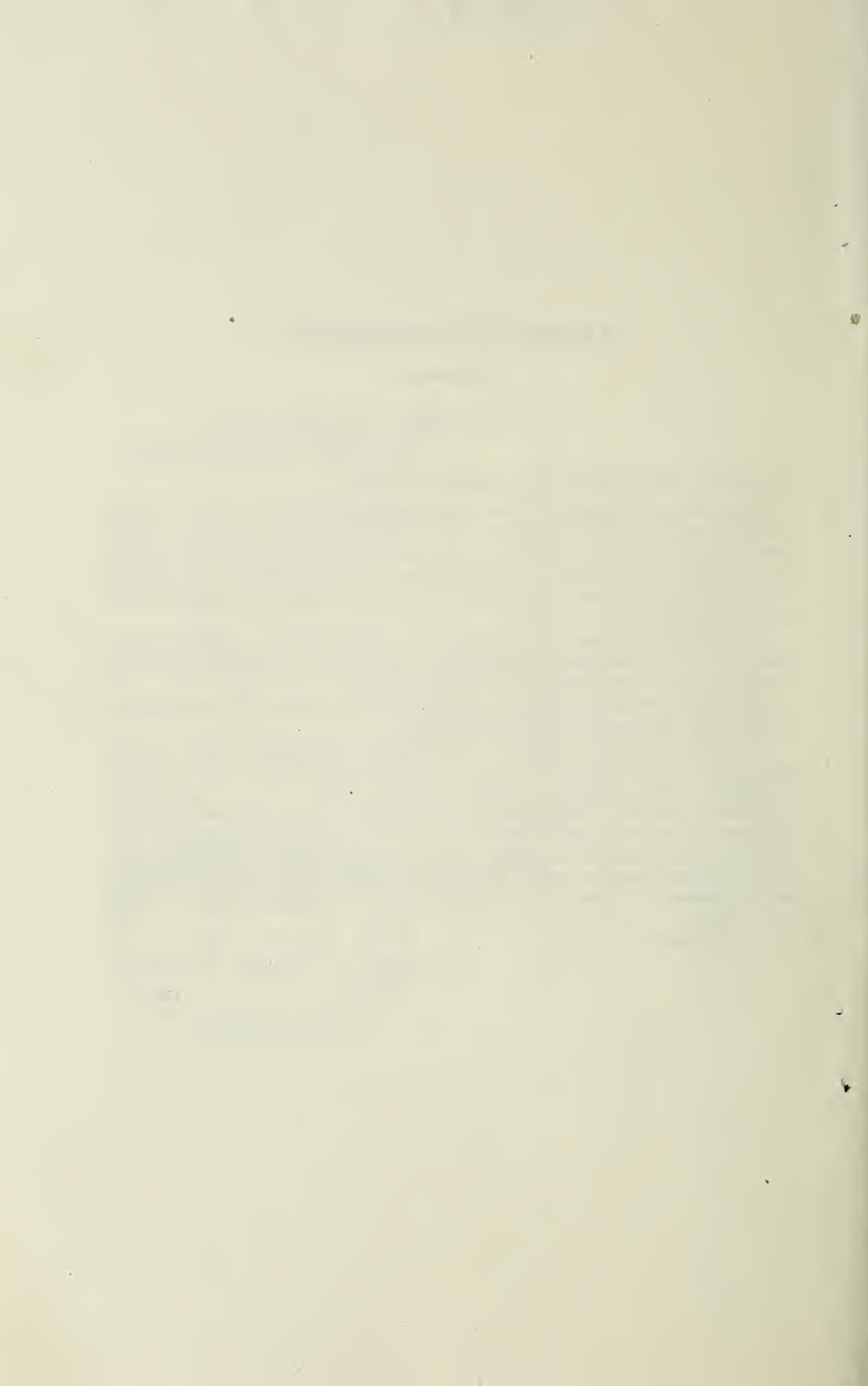
I recommend that the Secretary of Agriculture be authorized to carry out the program of runoff and waterflow retardation and soil erosion prevention proposed in this report.

Enclosed are comments received from Governors of the concerned States and interested Federal agencies.

The Bureau of the Budget, in its letter of March 6, 1952, advises that there is no objection to the submission of this report to the Congress. The Bureau further advises that it is in agreement with the objective contemplated in the report of carrying out measures designed to retard floods and prevent soil erosion, and that this objective is particularly desirable from the point of view of coordination of upstream measures with the flood control programs of the Corps of Engineers. A copy of the letter from the Bureau of the Budget is enclosed.

Sincerely,

CHARLES F. BRANNAN, *Secretary.*





## DELAWARE RIVER WATERSHED, NEW YORK, PENNSYLVANIA, NEW JERSEY, DELAWARE, AND MARYLAND

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LETTER FROM THE BUREAU OF THE BUDGET TO THE SECRETARY  
OF AGRICULTURE

EXECUTIVE OFFICE OF THE PRESIDENT,  
BUREAU OF THE BUDGET,  
*Washington 25, D. C., March 6, 1952.*

The honorable the SECRETARY OF AGRICULTURE.

MY DEAR MR. SECRETARY: This will acknowledge receipt of Acting Budget Officer J. L. Wells' letter of January 22, 1952, requesting advice as to the relationship to the President's program of the proposals contained in your Department's report entitled "Survey Report, Delaware River Watershed, New York, Pennsylvania, New Jersey, Delaware, and Maryland."

Erosion, floodwater, and sediment damages occurring in the Delaware River watershed are estimated to average \$4,622,300 annually. The principal losses, estimated to average \$2,444,600 annually, are caused by sheet erosion and inundation of agricultural land. Sediment damages to reservoirs and transportation facilities are estimated at \$898,100. Inundation of nonagricultural areas accounts for the balance of the estimated damage (\$1,279,600).

It is proposed to alleviate these damages and to realize extensive associated benefits by installing a number of interrelated and interdependent soil and water conservation and control measures during a 20-year period. These measures, applied in proper combination with other soil and water conservation practices and measures, would constitute a basic system of soil- and water-conservation in accordance with needs and capabilities of the land in the Delaware River watershed. Educational assistance and technical services are also recommended as a part of the proposed program.

The estimated cost of the recommended program, based on 1949 prices, is \$64,382,000. The Federal Government would be expected to expend \$32,766,000 of the total cost, and local interest would contribute \$31,616,000 or its equivalent in labor, materials, equipment, land easements, and other assistance in lieu of cash payments. Operation and maintenance of the recommended works of improvement are estimated to cost \$7,614,000 annually, of which the Federal Government would provide \$151,000, and \$7,463,000 or its equivalent would be borne by landowners and local interests.

It is estimated that the recommended watershed program, if installed as planned and maintained adequately, will yield average annual benefits evaluated at \$22,598,100. Reduction in erosion, inundation, and sediment damages is estimated at \$2,868,000, while conservation benefits are estimated at \$19,729,500. The conservation

benefits would result mainly from the provision of farm waterways, terraces, pasture and woodland development, and other conservation measures.

The total average annual costs of the recommended land treatment measures are estimated at \$10,213,591. Since prices are expected to vary during the 20-year installation period, both benefits and costs were adjusted to anticipate future price levels by applying indexes provided by the Bureau of Agricultural Economics. The effect of this adjustment or alternate evaluation is to reduce monetary values of both benefits and costs. Thus, the average annual benefits are adjusted to \$10,729,493 and the costs, on the same basis, to \$6,226,384. This adjustment results in a revised benefit-cost ratio of 1.72 to 1.0 for the recommended program.

The report has been reviewed by the Governors of New York, Pennsylvania, New Jersey, Delaware, and Maryland and also by the several concerned Federal agencies, in accordance with policies and procedures for distribution and coordination of reports as adopted by the Federal Inter-Agency River Basin Committee. The views expressed are generally favorable to the proposed program, with suggestions limited to considerations that could be resolved cooperatively by the concerned agencies or local interests during the periods of planning and installing the watershed works of improvement.

The work envisioned in the report constitutes principally open land, farm, and woodland improvement measures which will produce high conservation benefits, accruing mainly to landowners and farm operators in the form of increased returns due to improved practices. The program recommended also includes an intensification, acceleration, and adaptation of land-treatment activities already in progress under going programs of the Department of Agriculture. These include such programs as the conservation and use program, authorized by the Soil Conservation and Domestic Allotment Act, approved February 29, 1936, as amended; the Soil Conservation Service's program of assistance to districts and other cooperators, authorized by the act of April 27, 1935; and State and private forestry cooperation, pursuant to the act of August 25, 1950, sections 1 through 5 of the act of June 7, 1924, and acts supplementary thereto.

The Bureau of the Budget is in agreement with the objective contemplated in the report of accelerating land-treatment measures and installing structural measures designed to retard floods and prevent soil erosion. This objective is particularly desirable from the point of view of coordination of upstream measures with the flood-control programs of the Corps of Engineers.

The measures contemplated to implement the proposed program may be grouped into two broad categories—land treatment measures and structural measures. The Bureau of the Budget is of the opinion that installation of the structural measures (shown in table 2, p. 23 of the report as "Stream-bank erosion control," "Diking," "Water retarding structures," and "Stream channel improvement") should be properly authorized under the Flood Control Act, as amended and supplemented. The Bureau also believes that the land treatment measures set forth in the report, since they are largely an acceleration of existing programs of the Department of Agriculture, should be financed under appropriations other than that for the Flood Control Act. This would avoid confusion in the presentation of the Depart-



ment's budgetary program, since many of the current land treatment programs of the Department have the objective of runoff and water-flow retardation and the prevention of soil erosion. To the extent that the acceleration of land treatment measures under existing authorities is not possible, we urge that adequate authorities for such acceleration be sought through amendment of those basic authorities.

Your staff, on the other hand, believes that the Department cannot properly meet its responsibilities under the Flood Control Act unless the full program envisioned in the report is authorized under that act. Your representatives, however, agreed that appropriations for land treatment phases implementing the program recommended in the report, upon approval by the Congress, generally, on the basis as submitted, would be sought as additions to going program appropriations of the agencies carrying on the work. Funds for structural works or measures would still be requested under the appropriation "Flood control." The total obligations for land treatment and structural measures in each authorized flood-control project area could, of course, be shown in a summary table to be presented in the program and performance section of the annual budget document.

Subject to the above understanding as to the method of presenting the budget for flood-control programs, there would be no objection to the submission of the proposed Delaware River watershed flood-control survey report to the Congress. In the event the report or any modification thereof is approved by the Congress, submission of requests for appropriations must be justified in accordance with the policy set forth in the President's letter of July 21, 1950, which directed that all civil public works be considered with the objective, as far as practicable, of deferring, curtailing, or slowing down those projects which do not directly contribute to national defense or to civilian requirements essential to the changed international situation, or as may later be modified.

In submitting the Department's report to the Congress, it will be appreciated if you include a copy of this letter.

Sincerely yours,

(Signed) ELMER B. STAATS,  
*Assistant Director.*

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LETTER FROM THE CHIEF OF ENGINEERS TO THE SECRETARY OF  
AGRICULTURE

DEPARTMENT OF THE ARMY,  
OFFICE OF THE CHIEF OF ENGINEERS,  
*Washington, September 26, 1951.*

The honorable the SECRETARY OF AGRICULTURE.

DEAR MR. SECRETARY: In accordance with request from the Assistant Secretary of Agriculture, enclosing for my information and comment the Department of Agriculture's survey report on the Delaware River watershed, New York, Pennsylvania, New Jersey, Delaware, and Maryland, I am pleased to submit the following comments.

The report recommends that the Federal Government intensify, accelerate, and adapt certain activities under the current programs of the Department of Agriculture, and additional measures not now regularly carried out in such programs, to complete a balanced runoff,

waterflow retardation, and soil erosion control program for the watershed. The total estimated installation cost of the program, based on 1949 prices, is \$64,382,000, including \$32,766,000 Federal and \$31,616,000 private. The non-Federal participation may be in the form of labor, materials, equipment, land easements, rights-of-way, and other contributions in lieu of cash payments. The estimated annual cost of operating and maintaining the recommended program is \$151,000 Federal, and \$7,463,000, or the equivalent, non-Federal. Estimated annual benefits total \$22,598,100, and include reductions in erosion, sediment and inundation damages, and benefits from land enhancement, increased crop, pasture, and woodland production, and savings in costs of such production. Based on adjustments to prices and costs expected in the period 1955-65, the report states that the ratio of average annual benefits to average annual costs is 1.7 to 1.0.

The plan for improvement of the Delaware River watershed presented in your report appears to have been planned with recognition of and to supplement the authorized program for flood control in the basin by the Corps of Engineers and should not affect the design of those projects. I believe that any adjustments referred to below, which may become necessary as your proposed program is developed in detail, can be coordinated between our agencies on a mutually satisfactory basis as the occasion arises.

The watershed improvement part of the program would apparently conserve and improve the lands of the basin, and, while it alone will not control floods, it should aid in waterflow retardation by retaining water on the lands, thereby supplementing other measures for flood control and water conservation. The benefits claimed for this major portion of your program for the Delaware River are large; but since they have been prepared on a different basis than that used by the Corps of Engineers in its reports on flood control and river basin improvement, I am unable to comment on the economics of this part of your program or on the practices, measures, and structures involved in it.

The remaining portion of your proposed program, involving about 6.6 percent of the aggregate estimated cost, includes stream-channel improvements, waterflow-retarding structures, and diking. The channel improvements and diking are relatively small and are obviously not designed to control major floods. The 133 water retarding structures are essentially small reservoirs and are stated in the report to control subwatershed areas averaging less than 2 square miles each, or a total of about 260 square miles compared with the 12,750 square miles of the Delaware River Basin. It is evident that their cumulative effect on flood flows in the basin will be quite small. However, the report states that "These structures will be used primarily to protect urban areas where flood damages are high and other measures are impracticable or inadequate." While these small structures may provide some relief from smaller flows, their ability to control major damaging floods is doubtful.

I am unable to comment specifically on the adequacy or the economic justification of the channel, water retarding, and diking improvements recommended, since plans, engineering data, and detailed cost estimates are not given in the report. The retarding structures, particularly when located above urban areas, should be constructed so as to provide a reasonable degree of dependability and safety, and their limitations should be made plain so as to avoid giving a false sense of



security and increasing local hazards to life and property. It is possible that small retarding works such as you propose may be desirable parts of a plan for river basin improvement; the Corps of Engineers favors such improvements when they are found to be sound from engineering and economic viewpoints.

It is my understanding that, in the event of authorization of this program by Congress, you intend to give consideration to these matters in the preparation of your detailed plans. In view of the effect of extensive upstream channel improvements on downstream flood problems and projects, I am sure that you recognize the need of coordinating your detailed plans for upstream work with downstream conditions and requirements. Further, should Congress authorize the program, and should your detailed planning indicate the desirability of any substantial increase in size of water retarding dams or areas controlled, it is believed that such modification should result from a joint investigation by our two agencies and a further recommendation to Congress.

A minor error is noted on page 17 of the appendixes. The Brandywine River should not be listed with the streams affected by the flood of May 23, 1942. However, the storm of August 9, 1942, caused serious damage along the Brandywine.

I appreciate the opportunity given me to review your report on the Delaware River Basin. Subject to the comments above, particularly regarding the need for coordinating the program and for establishing its engineering adequacy and economic feasibility, I am in accord with the general type of program set forth.

Very truly yours,

LEWIS A. PICK,  
*Lieutenant General, Chief of Engineers.*

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LETTER FROM THE DEPARTMENT OF THE INTERIOR TO THE  
SECRETARY OF AGRICULTURE

DEPARTMENT OF THE INTERIOR,  
OFFICE OF THE SECRETARY,  
*Washington 25, D. C., August 9, 1951.*

Hon. CHARLES F. BRANNAN,  
*Secretary of Agriculture, Washington 25, D. C.*

MY DEAR MR. SECRETARY: In accordance with Federal Inter-Agency River Basin procedures, Assistant Secretary Hutchinson transmitted by letter dated May 4, 1951, for the information and comments of the Department, copies of the Department of Agriculture's survey report on the Delaware River Watershed, New York, Pennsylvania, New Jersey, and Delaware.

The report recommends that a program of runoff and waterflow retardation and soil-erosion prevention be installed in the Delaware River watershed at an estimated total cost during a 20-year period of some \$64,000,000, of which some \$32,800,000 would be the cost to the Federal Government, and about \$31,600,000, or its equivalent, to local interests. The program will be operated and maintained at an estimated annual cost of \$151,000 to the Federal Government and

an estimated annual cost of \$7,463,000 or its equivalent, to local interests making an estimated total annual cost of \$7,614,000. The ratio of the average annual benefit to the average annual cost is given as 1.72 to 1.

In accordance with Federal Inter-Agency River Basin Committee procedures, the report has been reviewed at field level by the Fish and Wildlife Service and the National Park Service. Opportunity for such field review is appreciated.

The omission of bibliographies of basic data and, in many instances, lack of reference to other agencies providing such data make the review and appraisal of some of the statements found in the report quite difficult. No reference is made to the need for collection of additional basic data, particularly hydrologic data. We feel that such data would be valuable for better defining present conditions and would aid in determining the effectiveness of the programs recommended.

The report does not indicate satisfactorily to the reviewer the means for determining the reduction in flood discharge estimated to be achieved by watershed management. As in previous reports, elaborate studies have been made, particularly in the computation of the expected reductions in floods, and the benefits to be obtained through application of the recommended program. Though some of the methodology is described, a number of assumptions or estimates have been made which may not be supported by adequate experience or findings.

In several instances it is implied that development of ungrazed forest soils in the watershed will reduce flood crests. In general such soils create a lag measurable in minutes or hours. During heavy precipitation such a soil probably would have no appreciable effect in reducing the flood crest.

In view of the extensive reduction in erosion claimed as a benefit from the program, it is recommended strongly that an adequate sediment load data program be established at an early date so as to provide a basis for determination, by actual observation, of the effectiveness of the erosion-control measures recommended. We would be pleased to consider collaboration with the Department of Agriculture in the establishment or extension of basic data and sediment load data collection programs in order to assure that all possible data will be available when planning final details of the various elements of the recommended program.

Due to the lack of details concerning plans of development for individual land and water areas, our comments relative to fish and wildlife conservation are necessarily of a general nature. Viewed in its entirety, the program would ultimately benefit fish and wildlife of the basin. However, unless fish and wildlife requirements receive due consideration, benefits to these resources may be only partially realized. Accordingly we are including all comments which seem pertinent to us, fully realizing that some of these points will be resolved prior to initiation of the program while others can be worked out if the Fish and Wildlife Service and the State conservation departments concerned are permitted to actively participate in the detailed planning for measures proposed.

Certain features of the program would probably result in losses in fish and wildlife resources on specific areas, at least in the early stages



of the program. We recognize that fish and wildlife benefits accrue incidentally in the usual application of the program. However, by placing greater emphasis on these resources and fully incorporating their development in the Delaware watershed program, much greater benefits could be attained. Land improvement should not be an end in itself, but should be directed toward achieving better crop production, flood control, flow conditions, etc. Improvement of fish and wildlife habitat should also be a definite goal of the subject program.

We note that in some instances the proposed program entails the removal of hedgerows or other obstructions, as well as trees and brush from certain pasture lands. The removal of hedgerows, trees, and brush may in many instances eliminate travel lanes and feeding areas and reduce the diversity of wildlife habitat which so often characterizes old fields and pastures. Furthermore, this operation may eliminate key winter cover which is so essential in the maintenance of wildlife populations. Such damages may be offset by the proposed conversion of 172,000 acres of open land to woodland by natural reseeding or by planting, provided the plantings are made in small blocks. Planting of shrubs on about 23,700 acres of field borders, as proposed, would be an excellent practice, and we are pleased to note that consideration is being given to planting multiflora rose as living fences in these areas. The placing of 2,126,400 acres of woodland under management would be of general benefit, but no mention is made of including any measures specifically for wildlife production. Public acquisition and rehabilitation of 167,000 acres of damaged headwater lands should also result in improvement of wildlife habitat.

The more even stream flows which are expected to result from the project would be of benefit to the fishery resources of the basin. Data concerning peak discharge reduction are included in the report, but details relative to the impact of the program on year-round stream flow conditions are lacking. It is assumed, however, that a better distribution of stream flows over the entire year would result. Improvement in flow conditions should improve fishing. Reduced scouring and sedimentation and improved food production and pollution conditions should result. In regard to sediment reduction the report provides several estimates, varying between 60 and 80 percent, on the amount that damages due to sedimentation will be reduced. Although tangible damages from sedimentation may be reduced by 60 to 80 percent, it does not necessarily follow that the rate of sedimentation would be reduced in that degree. Sedimentation might well remain a factor limiting fish production even though dredging costs, water treatment costs, and highway maintenance costs due to sedimentation are all drastically reduced.

Of particular concern to fishery activities is the proposal to construct 133 water-retarding structures. The report indicates that these structures would be located primarily above urban localities and would control very small drainage areas. These earth-fill dams would be equipped with a spillway adapted to site conditions and would have a low elevation outlet conduit which would be uncontrolled by gates or valves. Total storage capacity would be about 3 inches of runoff from the upstream watershed. In the report it is stated that all of the structures of this type would have a conservation pool.

In order to maintain a conservation pool and at the same time provide an uncontrolled outlet conduit it necessarily follows that the ele-

vation of the conduit must be at a higher elevation than the natural stream bed. Under these conditions the impoundments could not be drained. Many of the dams might serve as barriers to upstre m fish migrations.

In some cases these structures would probably be harmful to fishing interests, in some cases beneficial, and undoubtedly in some cases they would not alter the status quo. If located on a trout stream, the water temperature could be increased, thus favoring warm-water species of fish; spawning areas could be denied to trout; and trout fishing sites could be inundated. On the other hand, if productive trout fishing exists only above the dam site, the dam might serve as a barrier to invading warm-water species. This phase of the program should be thoroughly investigated at each of the 133 locations in order to ascertain the effect on the fisheries and make recommendations to the planning agency.

The Department endorses the purposes and objectives of the report. The proposed program would benefit the fish and wildlife resources of the Delaware River Basin. However, we wish to emphasize that full participation by the Fish and Wildlife Service and State game and fish departments concerned in the preparation of work plans to carry out this proposed program would greatly increase the benefits without detracting from the main objectives of the program. Further, we urge that an adequate sediment load data program be established so as to provide a basis for evaluation of the effectiveness of the erosion-control measures recommended.

The Geological Survey of this Department would be pleased to collaborate with the agencies of your Department in the establishment of such a program.

Opportunity for review of the report is appreciated.

Sincerely yours,

MASTIN G. WHITE,  
*Acting Assistant Secretary of the Interior.*

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LETTER FROM THE PUBLIC HEALTH SERVICE, FEDERAL SECURITY  
AGENCY, TO THE SECRETARY OF AGRICULTURE

FEDERAL SECURITY AGENCY,  
PUBLIC HEALTH SERVICE,  
*Washington 25, D. C., August 1, 1951.*

HON. CHARLES F. BRANNAN,  
*The Secretary of Agriculture,*  
*Washington 25, D. C.*

DEAR MR. SECRETARY: Pursuant to the policies and procedures established by the Federal Inter-Agency River Basin Committee, we have reviewed the preliminary report furnished by your Department entitled "Survey Report, Delaware River Watershed," dated October 1950. We have no comments to offer and find nothing in this report which conflicts with our water pollution control policy.

Sincerely yours,

M. D. HOLLIS,  
*Chief Sanitary Engineering Officer, PHS,*  
*FSA Member, Federal Inter-Agency River Basin Committee.*



LETTER FROM THE GOVERNOR OF DELAWARE TO THE ASSISTANT  
SECRETARY OF AGRICULTURESTATE OF DELAWARE,  
EXECUTIVE DEPARTMENT,  
*Dover, July 25, 1951.*HON. KNOX T. HUTCHINSON,  
*Assistant Secretary, United States Department of Agriculture,  
Washington, D. C.*

DEAR MR. HUTCHINSON: I have reviewed with the director of the agricultural extension service of the University of Delaware, Mr. George M. Worrilow, and the chairman of the Commission on Interstate Cooperation of Delaware, Mr. Clayton Hoff, the survey report of the Delaware River watershed regarding a program for runoff and waterflow retardation and soil-erosion prevention.

Delaware would like to share in this project and will give its enthusiastic cooperation in order to assure the success of such a project.

I appreciate your making this information available to us and I want to thank you for your leadership and interest in this matter.

Cordially yours,

ELBERT N. CARVEL, *Governor.*

LETTER FROM THE CHAIRMAN OF THE FEDERAL POWER  
COMMISSION TO THE SECRETARY OF AGRICULTUREFEDERAL POWER COMMISSION,  
*Washington 25, July 19, 1951.*

Subject: Delaware River Watershed.

HON. CHARLES F. BRANNAN,  
*Secretary of Agriculture,  
Washington 25, D. C.*

DEAR MR. SECRETARY: The comments herein with respect to your Department's survey report on the Delaware River watershed, New York, Pennsylvania, New Jersey, and Delaware, are transmitted in response to Assistant Secretary Hutchinson's letter of May 4, 1951. The transmittal of these comments is in accordance with the established procedures of the Federal Inter-Agency River Basin Committee.

The survey report recommends that a program of runoff and waterflow retardation and soil-erosion prevention be installed in the Delaware River watershed. The recommended program, which would consist of improvements in land use and management, minor structures for flood and erosion control, and other measures, would be developed over a 20-year period at an estimated cost of \$32,766,000 to the Federal Government and \$31,616,000 to local interests, making a total cost of \$64,382,000. It is stated in the report that on the basis of prices and costs expected to prevail under intermediate employment levels during the period 1955-65, the ratio of average annual benefit to average annual cost would be 1.72 to 1.

The Commission staff has reviewed the report of your Department and advises that the recommended improvements would not be adaptable to the development of hydroelectric power. Although the program includes some 133 water-retarding structures to provide temporary storage of excess runoff, the report states that the drainage

areas above the sites will average less than 2 square miles. These structures, therefore, would not be suitable for use in connection with the development of water power or the provision of storage reservoirs. The remaining items of the program are concerned primarily with changes in land use and management practices and are therefore not directly related to power development.

The staff reports that a substantial amount of hydroelectric power has been developed in the Delaware River Basin, largely on Wallenpaupack Creek and the Mongaup River, and that a large additional amount of power is possible of future development in the watershed. The staff is of the opinion that the recommended program of flow retardation and soil-erosion prevention would have a small but generally beneficial effect on existing and potential water-power developments, although the report does not contain sufficient quantitative analyses to indicate the expected improvement of stream flow conditions within the basin.

Based on its consideration of the report of your Department and on the studies by its own staff, the Commission concludes that the recommended improvements would not be adaptable to hydroelectric power development and that the proposed program would have a small but generally beneficial effect on existing and potential water-power developments in the Delaware River watershed.

Sincerely yours,

MON C. WALLGREN, *Chairman.*

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LETTER FROM THE GOVERNOR OF PENNSYLVANIA TO THE  
ASSISTANT SECRETARY OF AGRICULTURE

COMMONWEALTH OF PENNSYLVANIA,  
GOVERNOR'S OFFICE,  
*Harrisburg, June 4, 1951.*

Hon. K. T. HUTCHINSON,  
*Assistant Secretary, Department of Agriculture,  
Washington, D. C.*

DEAR MR. HUTCHINSON: This will acknowledge your letter of May 4 enclosing a confidential survey report on the Delaware River watershed. I have had this report and the supplemental information reviewed by the Pennsylvania Secretary of Agriculture and Secretary of Forests and Waters.

I am advised that the facts presented in this report are in line with the program being sponsored by the Pennsylvania Soil Conservation Commission; also by the agencies cooperating with this Commission in the general field of conservation of land and water resources namely the Department of Forests and Waters, the Pennsylvania Game Commission, Pennsylvania Fish Commission, Pennsylvania Department of Highways, Pennsylvania Department of Agriculture and the United States Soil Conservation Service.

The work of these State agencies combined with the programs of the Federal agencies have contributed much of the work as outlined in this report.

The broad educational program on conservation is being carried on throughout the entire area of the Delaware River watershed by the

extension representatives of Pennsylvania State College and by the vocational agricultural division of the Department of Public Instruction.

With best wishes,  
Sincerely,

JOHN S. FINE, *Governor.*

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LETTER FROM THE SECRETARY OF NEW JERSEY DEPARTMENT OF AGRICULTURE TO THE ASSISTANT SECRETARY OF AGRICULTURE

STATE OF NEW JERSEY,  
DEPARTMENT OF AGRICULTURE,  
*Trenton, N. J., May 14, 1951.*

MR. K. T. HUTCHINSON,  
*Assistant Secretary of Agriculture,*  
*Washington, D. C.*

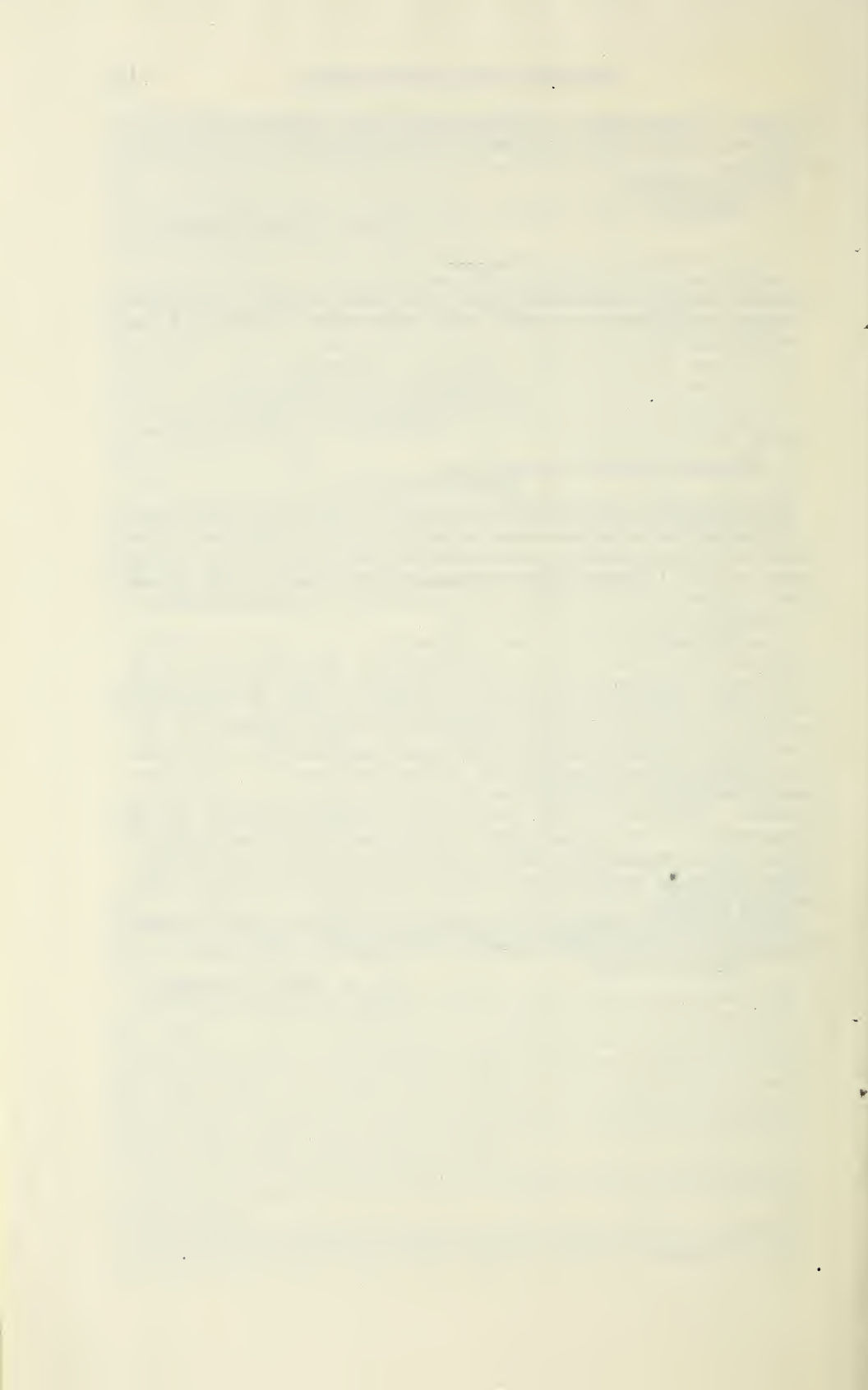
DEAR ASSISTANT SECRETARY HUTCHINSON: Your letter and report to Governor Driscoll have been referred to me by the Governor's office for reply. I refer to the Department of Agriculture survey report on the Delaware River watershed, authorized by the Flood Control Act of 1936 as amended and supplemented by the act approved August 28, 1937.

A careful study of the report indicated to me that an excellent program of flood and erosion control could be developed as a result of the report and that in this State we will very likely use the report for projects affecting the Delaware River watershed. However, basically, this State, through legislation, is vitally interested in the development of the Delaware River watershed through a four-State pact agreement known as Incodel, and any program that this State would inaugurate would have to be integrated with the programs of Incodel. Therefore, for the time being, this State approves of the Department of Agriculture survey report on the Delaware River watershed in principle but will no doubt feel that the wiser policy to follow will be to work through Incodel rather than starting an independent project.

Please accept my thanks for transmitting the information contained in the survey report, which I assure you is greatly appreciated.

Sincerely yours,

W. H. ALLEN, *Secretary.*



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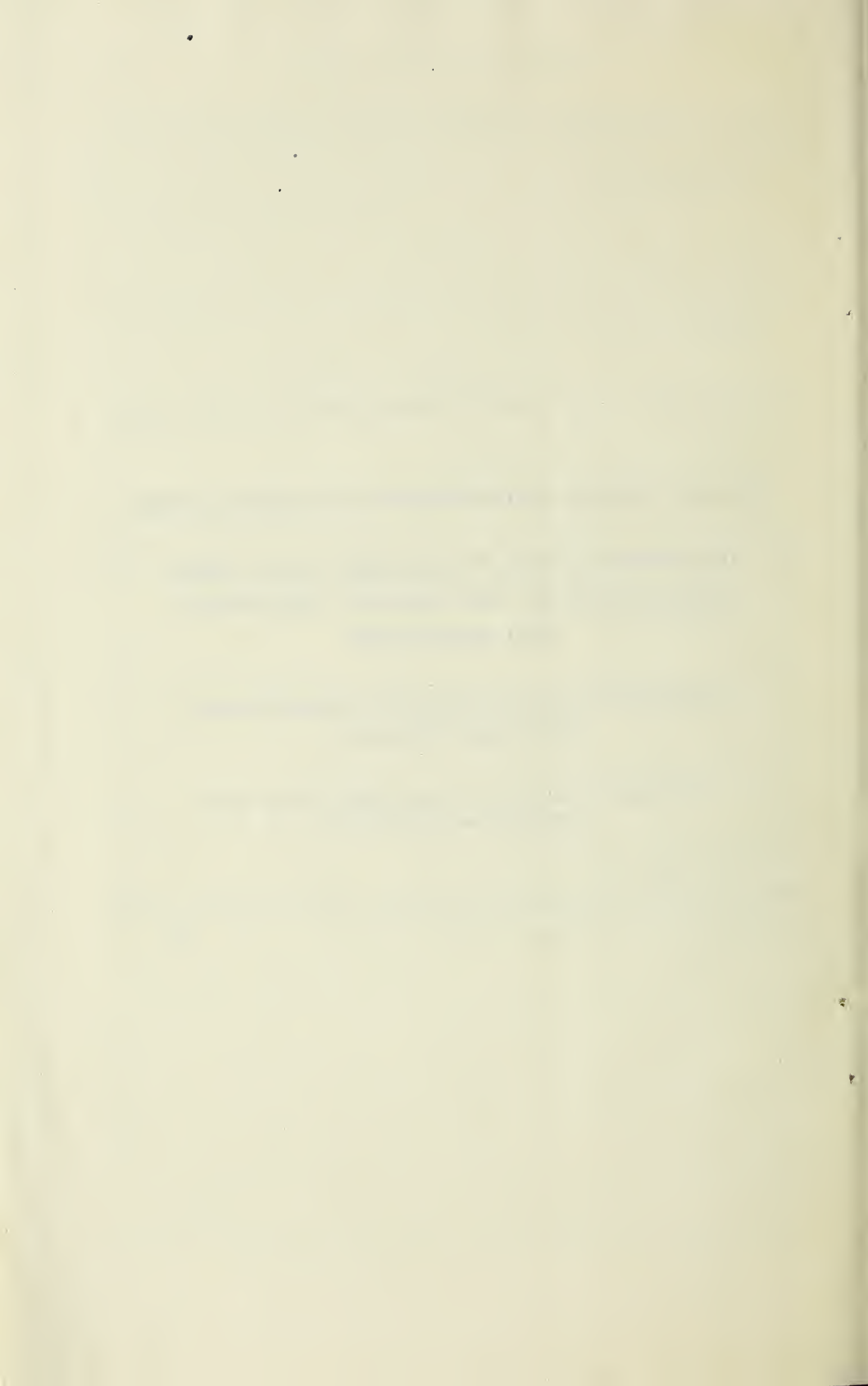
UNITED STATES DEPARTMENT OF AGRICULTURE

DELAWARE RIVER WATERSHED, NEW YORK,  
PENNSYLVANIA, NEW JERSEY, DELAWARE,  
AND MARYLAND

Program for Runoff and Waterflow Retardation and  
Soil-Erosion Prevention

Pursuant to the act approved June 22, 1936 (49 Stat. 1570)  
as amended and supplemented





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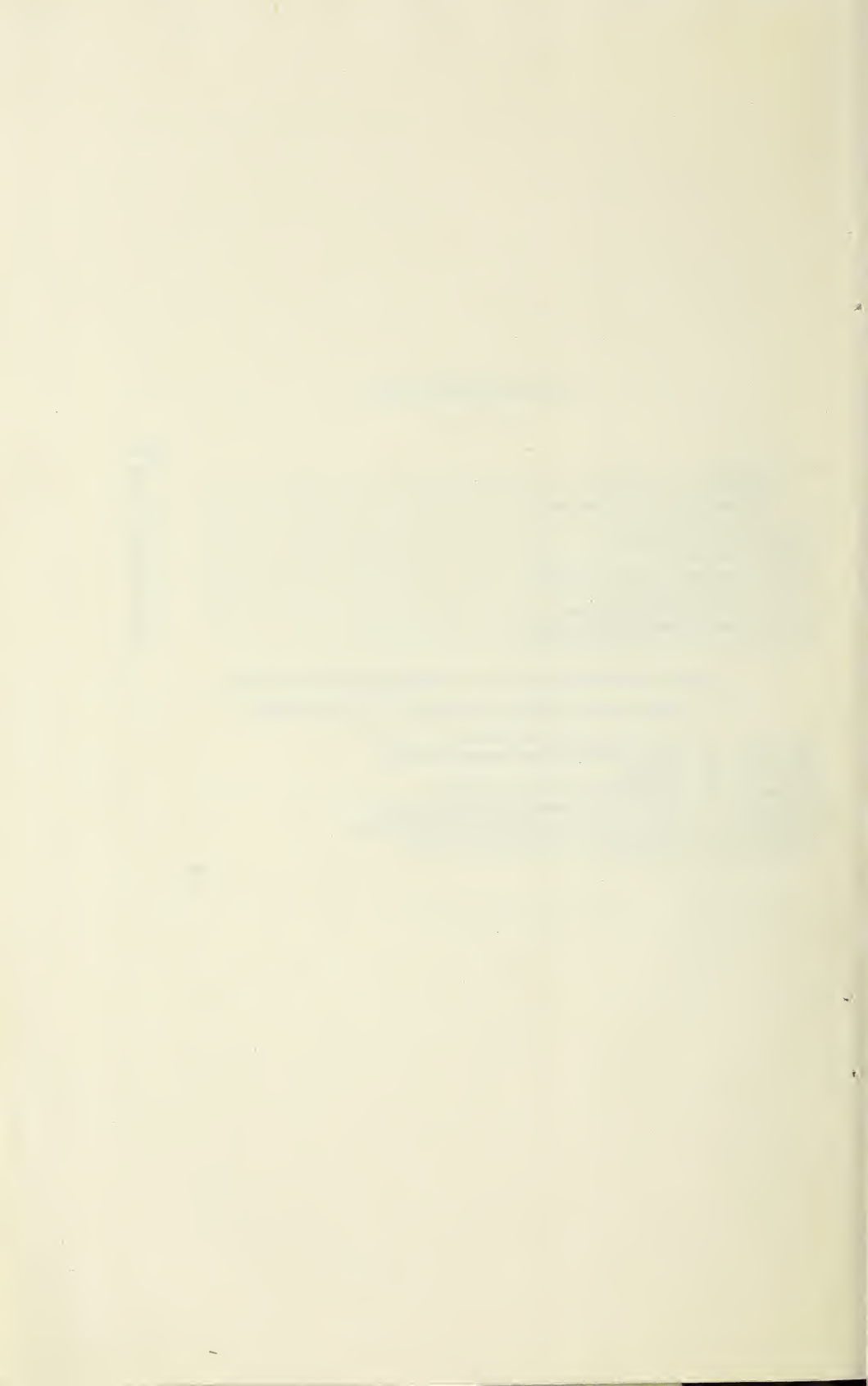
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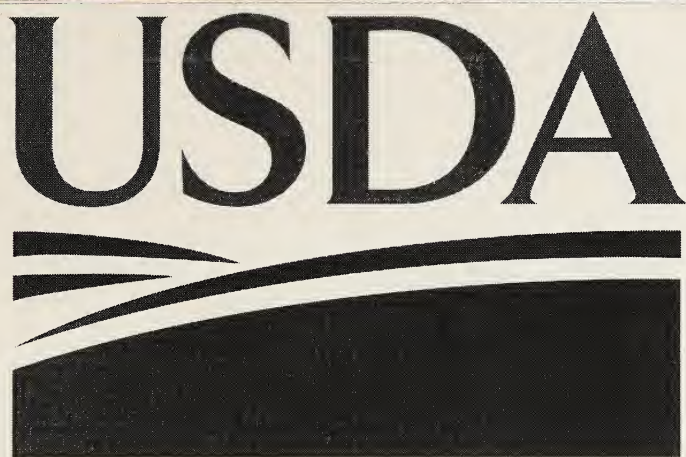
### LIST OF APPENDIXES MADE IN CONNECTION WITH REPORT

(These appendixes are not printed in this document)

- Appendix I. Description of the watershed.
- Appendix II. Flood, sediment and erosion damage.
- Appendix III. Program.
- Appendix IV. Physical effect of the program.
- Appendix V. Cost of the recommended program.
- Appendix VI. Benefits of the recommended program.
- Appendix VII. Comparison of benefits and costs.

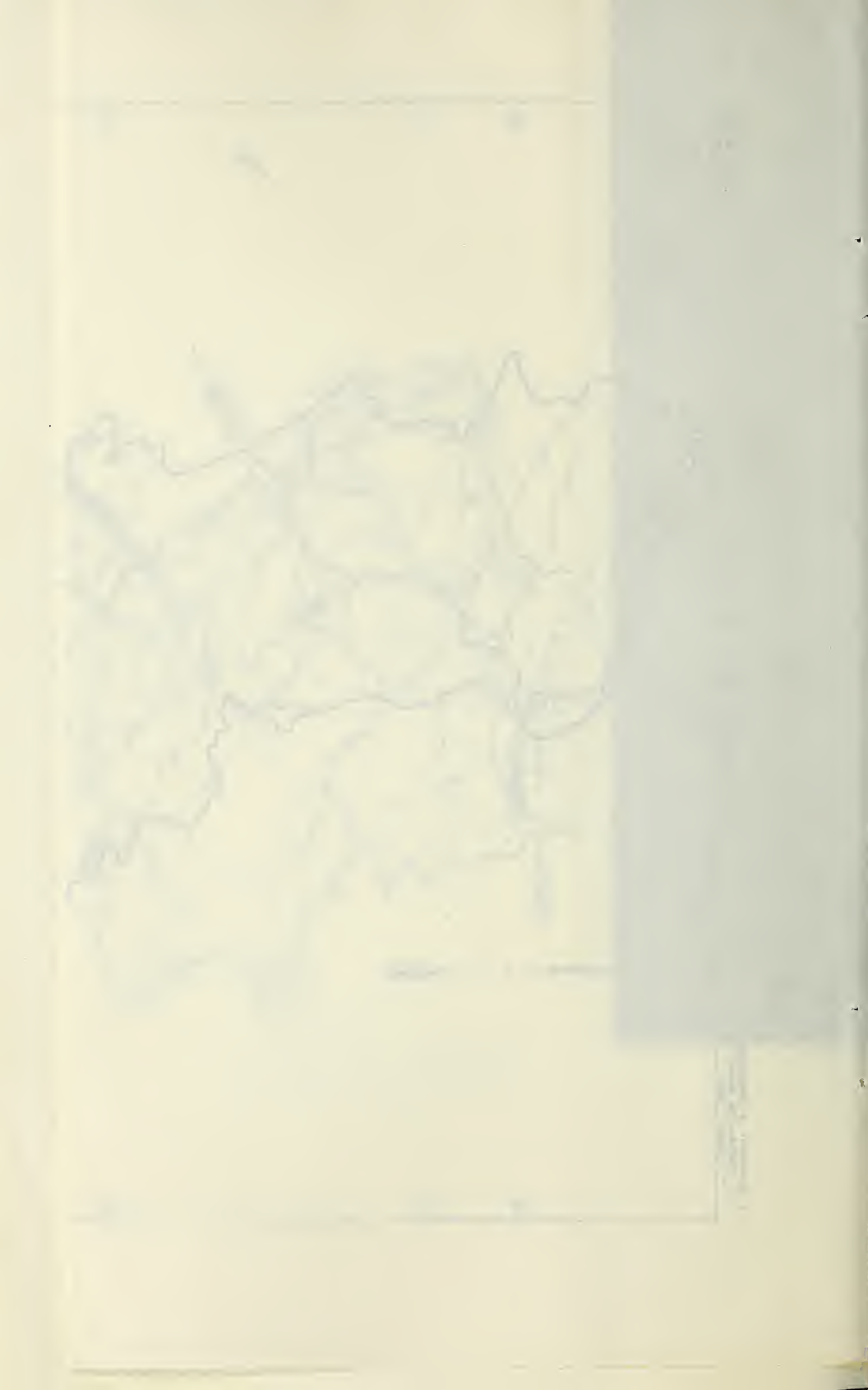






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# DELAWARE RIVER WATERSHED, NEW YORK, PENNSYLVANIA, NEW JERSEY, DELAWARE, AND MARYLAND

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## INTRODUCTION

### *Authority*

This report is submitted under the provisions of the act approved June 22, 1936 (49 Stat. 1570), as amended and supplemented.

### *Purpose and scope of report*

The purpose of this report is to outline a program of runoff and waterflow retardation and soil-erosion prevention for the Delaware River watershed in New York, Pennsylvania, New Jersey, Delaware, and Maryland; and to present recommendations for installing and maintaining the program, together with an analysis of the costs and benefits.

The Delaware River has a watershed area, excluding Delaware Bay, of 12,765 square miles, of which approximately 18 percent is located in New York, 50 percent in Pennsylvania, 23 percent in New Jersey, 8 percent in Delaware, and 1 percent in Maryland.

## RECOMMENDATIONS

It is recommended that a program of runoff and waterflow retardation and soil-erosion prevention be installed in the Delaware River watershed in New York, Pennsylvania, New Jersey, Delaware, and Maryland during a 20-year period at an estimated cost of \$32,766,000 to the Federal Government, and at an estimated cost of \$31,616,000 or its equivalent<sup>1</sup> to local interests, making an estimated total cost of \$64,382,000 for the installation of the recommended program.

The program will be operated and maintained at an estimated annual cost of \$151,000 to the Federal Government, and an estimated annual cost of \$7,463,000 or its equivalent to local interests, making an estimated total annual cost of \$7,614,000.

It is estimated that the recommended program will yield an average annual benefit of \$22,598,100 based on 1949 prices. With prices and costs expected to prevail under intermediate employment levels during the period 1955-65, the ratio of the average annual benefit to the average annual cost is 1.72 to 1.

The program herein recommended includes the intensification, acceleration, and adaptation of certain activities under current programs of the Department of Agriculture, and additional measures not now regularly carried out in such programs, all of which are necessary to complete a balanced runoff and waterflow retardation and

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<sup>1</sup> Labor, materials, equipment, land easements, rights-of-way, and other contributions in lieu of cash payments.

erosion-control program for the watershed. It is recommended that the Secretary of Agriculture be authorized to carry out this program. Although the current activities of the Department primarily related to the Flood Control Act are not included in the program herein specifically recommended, this program is based on the continuation of such current activities at least at their present level.

The recommended program includes certain adjustments in land use in accordance with the needs and capabilities of the land and the following practices and measures: contour strip cropping, cover cropping, diversions and terraces, outlets and waterways, establishing perennial hay, pasture management, contour furrowing, stream-bank erosion control, erosion control structures, woodland management, tree and shrub planting, land acquisition, stream channel improvement, water retarding structures, and diking.

Technical services will be made available for planning and applying the necessary land use adjustments, for planning and applying conservation measures on the watershed, and for integrating the measures included in the recommended program. Educational assistance, to facilitate the establishment of measures on a subwatershed basis, will be provided as a part of the recommended program.

The Secretary of Agriculture may make such modifications or substitutions of the measures described herein as may be deemed advisable due to changed physical or economic conditions or improved techniques whenever he determines that such action will be in furtherance of the objectives of the recommended program.

The recommended measures will be installed and maintained on a tributary or subwatershed basis under cooperative arrangements with individuals, and with state and local governments, soil conservation districts, or other agencies acceptable to the Secretary of Agriculture.

The authority of the Secretary of Agriculture to prosecute the recommended program shall be supplemental to all other authority vested in him, and nothing in this report shall be construed to limit the exercise of powers heretofore or hereafter conferred on him by law to carry out any of the measures described herein or any other measures that are similar or related to the measures described herein.

The Secretary of Agriculture may construct such buildings and other improvements as are needed to carry out the measures included in the recommended program.

#### DESCRIPTION OF WATERSHED

The Delaware River rises on the western slopes of the Catskill Mountains in southeastern New York and flows, as the East Branch and the West Branch, in a southwesterly direction to Hancock, N. Y., where the two branches unite. Thence the river flows in a general southeasterly direction to Port Jervis, N. Y., forming the boundary between the States of New York and Pennsylvania. From Port Jervis the river flows generally south to Trenton, N. J., where it becomes tidal. From Trenton, the Delaware continues, first in a southwesterly direction, past Philadelphia, Pa., to Wilmington, Del., and thence in a southeasterly direction to Delaware Bay and the Atlantic Ocean. From Port Jervis to near Chester, Pa., the river forms



the boundary between New Jersey and Pennsylvania and from this point to the sea it forms, with the Delaware Bay, the boundary between the States of New Jersey and Delaware. The two major tributaries of the Delaware River are the Lehigh River, with a drainage area of 1,370 square miles, and the Schuylkill River, with a drainage area of 1,910 square miles.

The Delaware River watershed is approximately 260 miles long from north to south, with a maximum width of 75 miles. The drainage area is 12,765 square miles, of which 2,969 square miles are in New Jersey, 2,362 in New York, 6,422 in Pennsylvania, 1,004 in Delaware, and the remaining 8 are in Maryland. Open land occupies 4,038,200 acres, or 49 percent of the watershed area, while 3,676,500 acres, or 45 percent of the area, is in woodland. The remaining 6 percent is accounted for by roads, urban areas, streams, and lakes.

The watershed was divided into three sections on the basis of topography, soils, types of agriculture, land use, and runoff characteristics. The upper part of the watershed is designated as the Upland section and includes 46 percent of the area. It is a hilly and mountainous area with long steep slopes. South of the Upland section is situated the Piedmont section, 31 percent of the area, where slopes are moderate and generally short. This section is intermediate between the Upland and Coastal Plain sections, as regards topography. Portions of the Coastal Plain are essentially level. The Coastal Plain section represents 23 percent of the watershed.

Annual precipitation, based on 26- to 71-year records, varies from 40 to 50 inches and is well distributed throughout the year. Average annual temperatures vary with elevation and distance from the ocean. The growing season ranges in length from nearly 200 days in the southern portion to approximately 100 days in the high elevations of the headwater areas.

Population of the watershed in 1940 was estimated at 4,700,000. This is concentrated in a number of cities, of which the four largest are Philadelphia, Pa.; Trenton, N. J.; Camden, N. J.; and Wilmington, Del.

Agriculture is one of the basic industries in the watershed. Dairying, truck farming, and poultry production are major enterprises. The nearness of Philadelphia and New York markets makes agriculture important in the watershed.

The importance of the watershed as a source of water for domestic and industrial purposes has been emphasized by the increased demand for water in New York City and the large metropolitan areas of New Jersey, Pennsylvania, and Delaware.

#### FLOOD PROBLEMS

Flood damages in the Delaware River watershed are of frequent occurrence. On some of the small tributaries, losses occur annually. These floods most commonly occur in the spring and early summer and the losses sustained are mainly to pasture and crops. Because of frequent flooding in some tributaries, the bottomland is used less intensively than its capability would otherwise permit. This type of damage represents an annual loss of potential net income of approximately \$240,000.

Much greater amounts of damage accrue from floods of less frequent occurrence. The July 1945 flood was typical of the floods caused by very intense local summer storms which do not usually create flood flows on the main stem or on the larger tributaries. Damages resulting from this flood, on the small tributaries in the vicinity of Easton, Pa., were in excess of \$4,000,000. Other recent floods of this type occurred August 1947 causing approximate damages of \$1,000,000 in the Calicoon Creek watershed and August 1945 causing approximately \$120,000 damages in the Chester Creek watershed. The May 1942 flood is typical of those produced by storms covering thousands of square miles and lasting two or more days. In such a flood large quantities of water are precipitated on the watershed, but rainfall intensities are not necessarily high. Damages caused by this flood were in excess of \$12,000,000 on the main stem of the Lehigh River and \$6,000,000 on the Lackawaxen River, as reported by the Department of the Army, Corps of Engineers, in House Document No. 587, Seventy-ninth Congress, second session, and House Document No. 113, Eightieth Congress, first session. Many more millions of dollars of damages occurred in other parts of the Delaware River watershed.

Damages caused by sedimentation occur mainly as increased dredging costs of navigable streams and harbors, increased maintenance costs of highways, and higher water-treatment costs. An estimated 2,300,000 cubic yards of eroded sediment are being deposited annually in the Delaware River. The cost of removal of that portion of the sediment which settles in navigable channels amounts to approximately \$747,500 per year. Eroded sediments affect highway maintenance costs by deposition in culverts and ditches, and on the highway surface. This impairment of drainage systems frequently results in wash-outs and other damages to highways. Cultivated farm lands are the major source of sediment. The greatest damage is caused by storms occurring during the early growing season when fields do not have sufficient protective cover. Deposition of sediment in low gradient stream channels and on adjacent bottomlands contributes to increased flood damage and intensifies land drainage problems.

Soil erosion in the Delaware River watershed, in addition to increasing maintenance costs of transportation systems and intensifying land drainage problems, seriously affects land productivity and crop production costs. Based on the present rate of soil erosion, the annual loss from reduced yields and increased production costs necessary to prevent yield declines is an estimated \$2,071,500.

Other damages caused by floods, while not evaluated in monetary terms in this report, include loss of life, illness, insecurity of property and income, disruption of public services, and disturbance of the general economic and social activity of the population.

Average annual damages are shown in table 1. These damages do not include those which will be prevented by current or authorized programs of public agencies.

TABLE 1.—*Estimated average annual monetary damage Delaware River watershed*

[1949 prices]	
Type of damage:	
Damage due to inundation:	
Agricultural.....	\$373, 100
Nonagricultural.....	1, 279, 600
Subtotal.....	\$1, 652, 700
Damage due to sediment:	
Harbor and channel dredging.....	\$747, 500
Highway.....	135, 000
Water treatment.....	15, 600
Subtotal.....	898, 100
Damage due to erosion.....	2, 071, 500
Total average annual damage.....	4, 622, 300

## ACTIVITIES RELATED TO FLOOD CONTROL

The Department of Agriculture through four of its agencies—Production and Marketing Administration, Forest Service, Extension Service, and the Soil Conservation Service—is presently engaged in several programs directly associated with floodwater retardation and soil-erosion prevention. An appraisal was made of these programs in the Delaware River watershed and certain portions were deemed of primary importance to the objectives of the Flood Control Act. It was found that the portions of the programs which involved changes in land use, strip cropping, cover cropping, diversions and terraces, outlets and waterways, establishing perennial hay, pasture improvement and management, contour furrowing, stream-bank erosion control, erosion-control structures, woodland management, tree planting, and protection of woodlands from fire and grazing effect reductions of floodwater and sediment damages.

The Production and Marketing Administration, with its agricultural conservation program of direct aids, offers financial assistance to farmers for the application of many of these practices and measures.

The Forest Service, cooperating with State forestry agencies in farm forestry<sup>1</sup> and in fire control and planting stock production,<sup>2</sup> is currently assisting states to establish sound forestry practices. The present fire protection is adequate.

The Department also cooperates with State extension services and experiment stations in educational and research work in the conservation of soil and water resources.

The Soil Conservation Service is furnishing technical services and incidental informational aids for the planning and installation of soil- and water-conservation practices and measures in cooperation with soil conservation districts.

The Department of Agriculture is now expending \$947,400 annually in the Delaware River watershed to carry out the portions of these programs which produce flood control and associated benefits.

Proposed for construction by the Department of the Army, Corps of Engineers, are two flood-control reservoirs in the Lackawaxen River

<sup>1</sup> Norris-Doxey Act (Cooperative Farm Forestry Act) of May 18, 1937 (50 Stat. 188).

<sup>2</sup> Clark-McNary Act of June 7, 1924 (43 Stat. 653), as amended.



watershed, one in the Lehigh River watershed, and local improvement works on the Lehigh River at Allentown and Bethlehem, Pa. Local protection works have been installed on the Rancocas Creek at Mount Holly, N. J.

The Commonwealth of Pennsylvania has under construction a channel improvement project on the Schuylkill River above Norristown. This project consists of the removal of culm deposits from the river channel and floodway and the construction of desilting basins. The Department of the Army, Corps of Engineers, is authorized to remove the culm from the Schuylkill River below Norristown, Pa.

The various States and other local public agencies administer and protect approximately 425,000 acres of forest land in the Delaware River watershed. In general, this land is managed to provide good watershed protection.

Soil conservation districts, organized under State laws, have been established in 29 of the 43 counties partly or wholly within the watershed. A land-use program has been developed by these districts.

The Interstate Commission on the Delaware River Basin, created by joint action of the States of Delaware, Pennsylvania, New Jersey, and New York, is making a study of the water resources of the watershed, which will result in recommendations for the development and conservation of these resources.

Within the watershed are numerous private associations and groups which have been organized to encourage conservation of soil, water, and forest resources and which are directly or indirectly concerned with flood control.

The benefits of the program herein recommended do not include the benefits afforded by these activities.

#### RECOMMENDED PROGRAM

The recommended program of runoff and waterflow retardation and soil-erosion prevention includes certain land use adjustments in accordance with the needs and capabilities of the land and the following practices and measures:

##### *Contour strip cropping*

The practice of growing hay or other close growing and soil conserving crops in contour strips, alternating with clean tilled or soil depleting crops, will be applied on approximately 870,000 acres of cropland. Contour tillage operations in conjunction with contour strip cropping will provide appreciable surface detention storage for runoff. Such a system will, in addition, keep at least half the sloping cropland in erosion resisting crops at all times, lessen the amount and velocity of runoff and the concentration of water in gullies or channels, thereby reducing the losses of soil by erosion.

##### *Cover cropping*

The practice of growing temporary crops to provide vegetative cover on land following the harvesting of clean-tilled crops until the next regular crop is planted will be applied on approximately 118,400 acres of cropland. A satisfactory vegetative cover will lessen the impact of raindrops on the soil, thus reducing erosion and maintaining the soil in condition to readily absorb water. The organic matter added to the soil by cover cropping will increase its water holding capacity.



*Diversions and terraces*

Approximately 3,040 miles of diversions and terraces will be installed to provide for intercepting surface runoff from sloping land and carry it in properly designed and constructed channels across the slopes to an outlet or waterway. Terraces will be installed on the more moderately sloping lands with short rotations. Diversions will be installed on the steeper slopes and in conjunction with less intensive rotations. The installation of these measures will furnish protection from damaging runoff to the lands lying immediately below and will significantly reduce erosion and sediment production.

*Outlets and waterways*

Adequate systems for the disposal of runoff water are a necessary part of the program to reduce floodwater and sediment damage. Approximately 6,480 acres of outlets and waterways will be established to provide for the safe disposal of runoff from terrace and diversion systems. This will result in reduced gully erosion and sediment production. The outlets and waterways will be vegetated and will include broad meadow strips and constructed channels. Supporting structures, required as a part of the disposal system, are described in another paragraph.

*Establishing perennial hay*

Approximately 281,430 acres of perennial grasses and legumes will be established to protect land not suitable for row crops and to protect such measures as diversions, and outlets and waterways. The success of this measure depends on the quality of the stand secured. Proper fertilization, therefore, is a definite part of the measure designed to secure an erosion-resisting crop. This measure, by increasing the infiltration rate, will reduce runoff and flood damage and, by protecting other measures, will reduce gully erosion and the resulting sedimentation.

*Pasture management*

Pasture management, consisting of mowing to remove weeds and mature grasses, the scattering of droppings, and the control of grazing intensity, will be applied on approximately 685,900 acres of pasture so that the improved vegetative cover will increase infiltration and reduce runoff. Fences will be used to facilitate the control of grazing intensity. Brush or other obstructions to mowing will be removed where feasible.

*Contour furrows*

Level furrows or small level terraces will be installed on approximately 147,100 acres of pasture land. The furrows will be spaced and constructed so that approximately one-half inch of runoff will be held in detention storage. In addition to reducing runoff, the installation of this measure will control erosion on sediment source areas.

*Stream bank erosion control*

Approximately 275 miles of eroding stream banks along minor tributaries will be controlled by the use of riprap and shrub plantings. Livestock will be excluded by either wire or multiflora rose fence. The establishment of this measure will halt the destruction of fertile bottomlands and will reduce the quantity of sediment getting into the streams.

*Erosion control structures*

Approximately 9,800 erosion control structures, including small check dams, gully structures, and culverts, will be installed as part of the water disposal system or for gully stabilization. Concentration of runoff requires special erosion control structures to protect the channels or natural drainageways from gullying and to furnish protection to railroad and highway ditches. New and larger culverts will be necessary to discharge runoff safely under railroad and highway fills. The establishment of this measure will reduce the rate of gully erosion in existing drainageways and permit the installation of adequate water disposal systems which will materially reduce sheet and gully erosion on the fields protected.

*Woodland management*

This measure provides for the intensification of management on all woodlands for the purpose of improving their hydrologic conditions. In the main, this improvement will consist of the development of a better forest floor. Under such conditions, infiltration rates will be greater, detention storage capacity will be increased, and the area of impermeable frozen soil will be reduced during the winter and spring. This will result in reducing the surface runoff and erosion from woodland areas.

Coincidental with hydrologic improvement, increased growth and stocking of woodlands will ultimately provide higher and more sustained income from these lands. Such returns will make it profitable for woodland owners to participate in the program and more than justify the costs involved.

Improved woodland management will be accomplished through an expanded program of technical services. These services will afford help in planning and applying woodland measures, including the preparation of management plans for 1,517,400 acres in private holdings and 168,000 acres to be acquired in public ownership. The plans will outline the steps necessary to operate woodlands efficiently and economically while integrating watershed protection and timber production objectives. Technical service and advice on timber marking will be provided to minimize clear cutting and destructive logging practices in harvest cuttings and to improve timber stands. These steps are necessary to develop and maintain the healthy soil conditions and vigorous growth needed to realize the objectives of the program. Additional technical service will be required on shallow soil woodland areas where cultural operations are needed to improve stand composition. Here the aim will be the development of thrifty, mixed stands of species whose litter is highly favorable for humus production, thereby contributing maximum quantities of organic matter to the soil as a means of increasing its moisture storage capacity.

Technical advice will be furnished the owners of 2,126,400 acres of woodland on logging methods which cause the least disturbance to woodland soil and drainage ways, including the proper installation and location of logging roads and skid trails. Existing roads and trails are sources of aggravated runoff and sedimentation as a result of poor location and inadequate drainage facilities. Correction of the unsatisfactory conditions resulting from past operations and the prevention of their recurrence in future operations is necessary if other woodland management practices are to be fully effective. This will

be accomplished by the installation of water spreading devices, small check dams, gully structures, and culverts. On 276,000 acres of noncommercial woodland where existing roads and trails are sources of runoff and sedimentation, this unsatisfactory condition will be corrected.

Livestock will be excluded from 71,000 acres of present farm woodland area and from 75,000 acres of land to be converted from openland to woodland as a part of woodland management. Grazing reduces the organic matter and compacts the soils of woodlands, thereby reducing seriously their infiltration and water-holding capacity. Grazing control must be instituted as an essential part of proper woodland management, if the previously mentioned installations and practices are to be effective.

To assure the cooperation of local owners in the installation and maintenance of good woodland management practices, advice and assistance will be given on the utilization and marketing of forest products.

#### *Tree and shrub planting*

The total woodland area will increase from 3,676,500 acres to 3,848,000 acres by the conversion of 172,000 acres of openland to woodland by natural reseedling or by planting. Tree planting is recommended for the establishment of a soil improvement and watershed protective cover on approximately 104,800 acres of openland which will not restock naturally within a reasonable length of time. Early establishment of a forest cover on these lands will reduce soil movement, increase infiltration rates, and enlarge soil moisture storage capacity. This planting is recommended on approximately 94,800 acres of private land and on about 10,000 acres of land to be acquired by public agencies.

Shrub planting is recommended on about 23,700 acres of field borders. Installation of this practice will provide good land cover in the partially shaded areas adjacent to woodlands and improve infiltration and soil moisture storage capacity, thereby reducing runoff and erosion.

#### *Land acquisition*

Public acquisition is recommended for approximately 167,600 acres of damaged headwaters land. These areas, normally well forested, have so been abused that they constitute critical floodwater sources and need major rehabilitation to restore the watershed cover for effective runoff and sediment control. Because of low productivity and the low returns to be derived from this land for many years, many landowners are not able to manage their land for either watershed protection or timber production. Public acquisition is an essential first step in insuring the establishment of necessary rehabilitational measures and providing continuity of management.

The objectives of the program can be met by acquisition by State or local governments. The land will be acquired through voluntary sales by owners in accordance with existing State policy.

#### *Stream channel improvement*

Approximately 423 miles of stream channel will be improved to reduce the damages resulting from inundation of valuable bottomland, furnish flood protection for high-value improvements, such as farm



buildings, and provide outlets for drainage works. The discharge capacity of stream channels will be increased by the removal of debris and sediment deposits, clearing and snagging, realinement, and bank sloping.

#### *Water retarding structures*

Approximately 133 upstream floodwater-retarding structures will be constructed to reduce inundation damage by providing temporary storage for flood runoff. Drainage areas above the structures will average less than 2 square miles. The structures will be earth-fill dams through which a small, low-elevation outlet conduit, uncontrolled by gates or valves, will be constructed to draw down the temporary storage. A spillway adapted to site conditions and meeting required design criteria will be used to provide an outlet for flood flow in excess of the storage capacity provided by the structure.

#### *Diking*

Seventeen miles of diking will be constructed to provide protection from inundation to valuable bottomland and to such improvements as highways and farm buildings where limitation of rights-of-way and gradients prohibits the use of channel improvement. Floodways will be provided to safely carry flood discharges of design frequency.

The quantities of measures included in the recommended program are based on total watershed needs less the estimated accomplishments under "going" programs over a 20-year period. Minor reductions in the acreages of clean-tilled and small-grain crops and large acreage increases in managed pasture, perennial hay crops, and farm woodlands will result from the installation of the recommended program.

#### *Educational assistance*

Landowners and operators and others in the watershed will be furnished educational assistance relative to the need for the recommended program and its purposes and objectives. Information will be supplied as to the manner in which landowners and operators now obtain services and assistance that are available through the various governmental agencies; and how they can and should, by their own efforts, contribute successfully and most economically to the accomplishment of the over-all objectives. Intensified educational efforts will be directed to familiarizing farmers with the specific practices and measures essential to runoff and waterflow retardation and soil-erosion prevention, how to install those measures not requiring the detailed assistance of a specialized technician, how to maintain them, and how to integrate them into the soundest farming system to produce the greatest benefit over a long period of time.

The Department is committed to a watershed and subwatershed approach in carrying out the recommended program. It is essential that educational assistance provided under this program be directed toward furthering the specific objectives of floodwater and sediment damage reduction and that it be fitted as to method and synchroniza-tion into subwatershed operations activities.

#### *Technical services*

Technical services will be provided for (1) planning and applying woodland improvement measures and management practices for watershed protection, (2) planning and applying land-use adjustments,

(3) planning and applying conservation measures on the farm, and (4) integrating the installation of individual measures into a proper combination to achieve the most effective program of runoff and waterflow retardation and soil-erosion prevention. These services are required to assist the people in the watershed in installing the recommended measures on their land and in adopting the recommended practices for their farm and woodland operations.

*Testing the effectiveness of the program*

The Department of Agriculture will conduct such investigations, design studies, detailed planning for program installations and evaluations of the effects of the recommended measures and practices as may be necessary to adapt them to watershed problems for accomplishing the objectives of the program in an efficient manner.

These investigations will be made on selected subwatersheds to determine the most effective methods for operating and maintaining the recommended measures and practices.

COST OF RECOMMENDED PROGRAM

The estimated cost of installing the recommended program in the Delaware River watershed is shown in table 2.

The Federal Government will bear approximately 51 percent of the total installation cost, State and local governments approximately 10 percent, and private interests approximately 39 percent.

TABLE 2.—Estimated cost of installing the recommended program, Delaware River watershed

[1949 prices]

Measure	Unit	Quantity	Total cost
1. Contour strip cropping.....	Acres.....	870,000	\$4,343,000
2. Cover cropping.....	do.....	118,400	1,657,000
3. Diversions and terraces.....	Miles.....	3,040	1,278,000
4. Outlets and waterways.....	Acres.....	6,480	3,031,000
5. Establishing perennial hay.....	do.....	281,430	13,492,000
6. Pasture management.....	do.....	685,900	9,036,000
7. Contour furrowing.....	do.....	147,100	2,256,000
8. Streambank erosion control.....	Miles.....	275	4,158,000
9. Erosion control structures.....	Number.....	9,800	5,002,000
10. Woodland management.....	Acres.....	2,126,400	10,718,000
11. Tree and shrub planting.....	do.....	128,500	3,520,000
12. Land acquisition.....	do.....	167,600	1,642,000
13. Stream channel improvement.....	Miles.....	423	2,824,000
14. Water retarding structures.....	Number.....	133	1,343,000
15. Diking.....	Miles.....	17	82,000
Total.....			64,382,000

The costs of testing effectiveness of program, administration of direct aids, technical services, and educational assistance are included in the above costs. The estimated costs for technical services and educational assistance amount to approximately 18.1 percent and 3.4 percent respectively of the installation cost of the recommended program. Of these amounts, non-Federal public agencies will bear one-half the cost of technical services on privately owned woodland and one-half the cost of educational assistance. The estimate includes about 1 percent of the total cost for testing the effectiveness of the program and 2.7 percent for the administration of direct aids.

The estimated average annual cost of operating and maintaining the recommended program is \$7,614,000. The Federal Government will bear approximately 2 percent of this annual maintenance cost to provide technical services necessary to assure proper use and conservation and management of lands. State and local governments will bear approximately 3.2 percent of this cost, and private interests will bear the remaining 94.8 percent.

#### BENEFIT FROM RECOMMENDED PROGRAM

The estimated average annual monetary benefit resulting from the recommended program when it attains maximum effectiveness is shown in table 3.

In addition to the benefits listed in table 3, there are many unevaluated benefits, such as saving of life and alleviating mental distress, improving community organizations and facilities, maintaining and increasing the tax base, improving recreational opportunities, and increasing fish and game production.

TABLE 3.—*Estimated average annual monetary benefit from the recommended program, Delaware River watershed*

[1949 prices]	
Type of benefit:	
Reduction in damage due to inundation:	
Agricultural.....	\$162, 600
Nonagricultural.....	556, 900
Subtotal.....	\$719, 500
Reduction in damage due to sediment:	
Harbor and channel dredging.....	\$448, 500
Highways.....	108, 000
Water treatment.....	10, 900
Subtotal.....	567, 400
Reduction in damage due to erosion.....	1, 581, 700
Land enhancement.....	240, 000
Other benefits: <sup>1</sup>	
Increased crop production.....	\$9, 369, 100
Increased pasture production.....	3, 268, 100
Increased woodland production.....	6, 018, 000
Savings in production costs.....	834, 300
Subtotal.....	19, 489, 500
Total.....	22, 598, 100

<sup>1</sup> Benefits which accrue to the owners and operators of the land on which the recommended program is installed.

#### COMPARISON OF BENEFIT AND COST

Based on prices and costs expected to prevail under intermediate employment levels during the period 1955-65, the ratio of the average annual benefit to the average annual cost of the recommended program is 1.7 to 1.







